

Functional outcomes following total laryngectomy and pharyngolaryngectomy: a 20-year single centre study

Authors

Thomas Layton¹⁻² Rachel Thomas², Carol Harris², Sam Holmes², Lisa Fraser², Priy Silva² and Stuart C Winter²⁻³

Authors institutions

¹The Kennedy Institute of Rheumatology, Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, University of Oxford, UK.

²Bleinheim Head and Neck Unit, Churchill Hospital, Oxford University Hospitals NHS Foundation Trust, Oxford, UK

³Nuffield Department of Surgical Sciences, University of Oxford, UK.

Corresponding Author

Thomas Layton MBChB BSc DPhil
Postdoctoral research fellow
Kennedy Institute of Rheumatology
NDORMS
University of Oxford
OX3 7 FY
07703684378
Thomas.layton@kennedy.ox.ac.uk

Author contributions

TL, RT, CH and SW conceived and designed the study. TL, RT, CH, LF, PS, SW and SH performed and contributed to the analysis of the experiments. TL, SW and RT wrote the manuscript with contribution from all co-authors.

Abstract

Background: Laryngeal cancer accounts for 1 per cent of all cancers in men and 0.3 per cent of all cancers in women. Pharyngolaryngectomy (TPL) and total laryngectomy (TL) are central surgical techniques in the management of advanced laryngeal malignancies but are associated with significant morbidity. In addition, optimal reconstruction following TPL remains an area of active research.

Methods: Here, we compared speech and swallowing outcomes following circumferential and partial pharyngeal resection alongside total laryngectomy in patients with laryngeal and hypolaryngeal tumours. We performed a systemic analysis of patient demographics, tumour characteristics, treatment modality and method pharyngeal reconstruction following TPL and TL leveraging data collected over a 20-year period at a large tertiary referral centre.

Results: Analysing 155 patients the results show circumferential pharyngeal defects and prior radiotherapy have a significant impact on surgical complications.

Conclusion: Pharyngeal resection carries a substantial risk of incurring impaired speech and swallowing in patients. Moreover, our results support poorer functional outcomes with more radical pharyngeal resections and show a clear trend towards worse swallowing outcomes in salvage surgery.

Introduction

Laryngeal cancer accounts for 1 per cent of all cancers in men and 0.3 per cent of all cancers in women¹⁻⁴. Overall, approximately 30-40% of patients present with locally advanced tumours (T3-T4) and the five year disease free survival is highly dependent on the disease stage and tumour location⁴. The management of advanced laryngeal and hypopharyngeal cancer has evolved over time with increasing application of organ preserving treatments including radiotherapy and chemo-radiotherapy^{5,6}. Nevertheless, surgery remains the principal treatment for most recurrent tumours following previous radiotherapy^{7,8}. In addition, dependent on patient factors surgery is also supported for laryngeal tumours invading the pharynx. For these locally invasive tumours pharyngolaryngectomy (PL) is an appropriate treatment modality comprising a total laryngectomy as well as removal of a portion (partial pharyngectomy, PPL) or circumferential segment of the pharynx (total pharyngectomy, TPL)⁹⁻¹¹.

As the upper aerodigestive tract is vital for competent swallowing and speech PL and TL are associated with a significant impact on patient quality of life^{8,11}. Therefore, while complete tumour resection is the core aim of surgery the importance of maximising functional outcomes following PL and TL is critical to foster evidence based surgical planning⁹⁻¹². Moreover, improved long term survival in advanced upper aerodigestive tract cancers has resulted in an increasing number of patients affected by the long term sequelae of impaired speech and swallowing¹³. Evidence has demonstrated that persistent dysphagia and dysphonia have a profound effect on patient quality of life and thus a detailed understanding of these outcomes is crucial¹⁴⁻¹⁶. Despite this, comprehensive analysis of functional outcomes following PPL and TPL are limited, and further work is required.

This study aimed to systemically analyse functional speech and swallowing outcomes in salvage and primary resections of the pharynx across a 20-year period at a single centre.

Methods

Following approval by the institute ethics approval board (module number #6748) the electronic clinical records of all patients with hypopharyngeal reconstruction for carcinoma of the hypopharynx or larynx between 1999 and 2020 at a single institute were reviewed.

Inclusion criteria included all patients free of distant or metastatic disease at the time of surgery and at six months post operatively. Patients were excluded with synchronous or metachronous tumours, those with incomplete documentation and patients lost to follow up. Clinicopathological factors were collected including patient age, gender, tumour laterality and location. At the time of initial histological diagnosis TNM tumour classification was defined using the contemporary AJCC edition.

Surgical intervention was either total laryngectomy (TL), total pharyngolaryngectomy (TPL) or partial pharyngolaryngectomy (PPL). PLP represented a subtotal pharyngeal resection with a remaining section of native mucosal connection between resection margins. TLP was a complete circumferential pharyngeal defect between resection margins. Salvage procedures were defined as any patient who had previously received radiotherapy with a curative intent. Reconstruction methods were classified as direct closure (DC), pedicled flap, free tissue transfer and intestinal pull up. Pedicled flaps were the pectoralis major, supraclavicular, facial artery musculomucosal (FAMM) and temporalis flaps. Free tissue transfer methods were anterolateral thigh (ALT) flap, free latissimus dorsi (LD) and radial forearm free flap (RFFF).

Swallowing outcomes were assessed using the MD Anderson Dysphagia Inventory (MDADI) score¹⁷ and the International Dysphagia Diet Standardisation (IDDSI) framework¹⁸. The MDADI was administered by written questionnaire and is a 5-item self-administered questionnaire that quantifies swallowing-related quality of life from 1 (low functioning) to 5 (high functioning). The IDDSI framework is culturally sensitive, measurable, and applicable to individuals of all age groups in all care settings. It consists of 8 levels where drinks are measured (0-4) and foods measured from 3-7. A score of 7 represents a 'normal' diet. Speech outcomes were graded by method of communication as surgical voice restoration (SVR), electrolarynx, mouthing and writing. Voice quality was stratified into tonic (normal), hypotonic (breathy), hypertonic (strained), no voice with SVR and no SVR. All speech outcomes were assessed by a specialist head and neck SALT team. For speech and swallowing outcomes our comparators were salvage versus primary procedures, the extent of the surgical resection (TL, PPL & TPL) and the method of reconstructive method use.

Statistics

All statistical analysis was performed using R (RStudio 3.5 Version). For comparisons of statistical significance between two variables a paired *t*-test was used and for multiple groups a one-way analysis of variance (ANOVA) test was used with an alpha of 0.05. For binary comparisons of categorical variables a χ^2 test was used. To test normality assumptions, we analysed the residuals of covariate linear models in addition to applying a Shapiro-Wilk test of normality. When normality assumptions were not met a Kruskal-Wallis test or Mann Whitney U test was used. All evaluates were two-tailed and value of $P < 0.05$ was considered statistically significant.

Results

Patient demographics and treatment overview

The study cohort contained 155 patients with 91 (%) males and 64 (%) females and a median age of 67.3 years (range 44-86). Patient characteristics, treatment, and outcome data are shown in Table 1. In all patients, there was 85 TLs, 32 PPLs and 38 TPLs. One patient with locally advanced chondrosarcoma was included however all other tumours were squamous cell carcinomas. Tumour resection was performed as a primary procedure in 68.4% (106/155) and as a salvage procedure in 31.6% (49/155). Postoperative radiotherapy was given to 44.2% (70/155). Seventy-two patients (46.5%) received no flap reconstruction in which the defect was closed primarily.

Tumour characteristics

Tumour characteristics are shown in Table 1. Tumor subtypes were supraglottis ($n=27$), glottis ($n=86$), subglottis ($n=6$), hypopharynx ($n=30$), posterior pharynx ($n=1$) and oesophageal ($n=4$). The histological grade was 10 (6.5%) well, 117 (75.5%) moderate and 27 (17.4%) poorly differentiated tumours. (Table. 1). The most common T stage was T4 ($n = 82$) followed by T3 ($n = 40$) then T2 ($n = 20$) and finally T1 ($n = 11$) and T0 ($n = 1$). T0 tumour was for a dysfunctional larynx post radiotherapy. NO ($n = 81$) was the most frequent nodal status, after this N2 ($n = 40$), then N1 ($n = 19$) and finally N3 ($n = 12$) and Nx ($n = 3$). No patient had distant metastasis at the time of surgery (MO, $n=155$) and all were alive 6 months after their surgery. Initial

staging at presentation was determined by endoscopy findings and imaging, and all confirmed primary T1-T2 tumours were subsequently downstaged following surgery.

Speech outcomes

With regards to SVR, 86.5% (134/155) underwent primary puncture, 3.2% (1/155) secondary puncture and 10.3% (16/155) did not undergo SVR. For voice outcomes, 63.8% (99/155) had an optimal ('tonic') voice, 5.81% (9/155) had a hypotonic voice, 3.87% (6/155) had a hypertonic voice, 14.2% (22/155) had a valve with no voice and 10.3% (16/155) did not have a speaking valve. The primary method of communication at 6 months post-operatively was SVR for 70.9% (110/155), using an electrolarynx for 8.39% (13/155), mouthing for 17.4% (27/155) and writing for 3.23% (5/155).

Comparing speech outcomes by resection status showed in TL 76.5% used SVR as the most common method of communication, as compared to 75% in PPL and 55.3% in TPL ($p=0.04$, Table 2-3). Only 1.2% of TL patients used writing to communicate, in contrast to 3.1% of PPL and 7.9% of TPL patients. In addition, 14.1% of TL, 15.6% of PPL and 26.3% of TPL patients used mouthing to communicate. There was a lower rate of achieving a normal voice in TPL when compared to PPL and TPL at 50%, 62.5% and 69.2% of patients, respectively ($p=0.76$). To account for defect characteristics (TL, PPL, TPL) we included the extent of resection as a covariate and explored speech outcomes by reconstructive method (Table 4). Free tissue transfers as compared to regional flaps increased successful use of a SVR in PPL (87.4%, $n=7$ vs 71.4%, $n=15$) and TPL (60%, $n=18$ vs 0%, $n=3$) ($p=0.01$). Moreover, evaluating speech quality for PPL demonstrated that 62.5% of patients receiving free tissue transfer and 61.9% a regional flap achieved a normal voice. In TPL, 60% of patients who received free tissue transfer and 0% of regional flaps achieved a normal voice. Therefore, in patients undergoing partial or circumferential defects there is a higher rate of normal speech with the use of free tissue transfer ($p=0.01$)

We observed a clear trend of worse speech outcomes following salvage procedures (Table 5-6). There was a lower rate of SVR use for salvage as compared to primary procedures at 62.7% and 75% respectively. Also, we noted a higher proportion of salvage patients mouthing (24.5% vs 14.2%) when compared to primary patients. Finally, the rate of a normal 'tonic' voice for

salvage procedures was 55.1% and for primary procedures was 67.1% ($p=0.24$). To account for defect characteristics, we included the extent of resection (TL, PPL, TL) as a covariate and examined speech outcomes by reconstructive method (Table 7).

Swallowing outcomes

The MDADI global score of all patients was 56.7% at 5/5, 20.6% at 4/5, 7.4% at 3/5, 10.3% at 2/5 and 4.55% at 1/5. With regards to IDDSI values, 1 patient had 0 (0.64%), 1 had 2 (0.64%), 3 had 3 (1.94%), 19 had 4 (12.3%), 20 had 5 (12.9%), 52 had 6 (33.5%), 57 had 7 (36.8%) and 2 patients (1.29%) were nil by mouth (NBM). In all patients, 2 (1.29%) were NBM at six months post-operatively, 57 (36.8%) were on a normal diet (IDDSI = 7) and 96 (61.9%) had a diet with a variable viscosity (IDDSI 0-6).

In TL, 43.5% (37/85) reached a normal diet, in PPL 34.4% (11/32) and in TPL it was 23.7% ($p=0.036$) (Table 7). Resection status demonstrated a significance difference in global MDADI score ($p=0.04$), with maximum score (5/5, high functioning) at 67.1% for TL, 50.0% for PPL and 39% for TPL. In PPL the use of free tissue transfers as compared to regional flaps showed an increased number with a normal voice at 37.5% ($n=7$) and 33.3% ($n=3$) respectively. For TPL patients, 50% with direct closure, 0% with regional flap, 23.3% with free tissue transfer and 25% with intestinal pull up achieved a normal diet. Therefore, together in patients undergoing partial or circumferential defects there is a higher rate of normal speech with the use of free tissue transfer ($p=0.04$).

The proportion of patients achieving a normal diet (IDDSI=7) was 32.7% for salvage procedures and 38.7% for primary procedures ($p=0.58$) (Table 8). One salvage patient (1.9%) and one primary (0.9%) primary patient were NBM at 6 months post op. There was a significant difference in global MDADI score by salvage status ($p=0.04$). For salvage procedures, 54.9% were 5/5, 11.7% 4/5, 5.8% 3/5, 17.6% 2/5 and 9.8% at 1/5. In contrast, for primary procedures 57.9% were 5/5, 25.0% 4/5 8.6% 3/5, 6.7% 2/5 and 1.9% 1/5.

Discussion

Gaining an understanding of which factors influence speech and swallowing in head and neck cancer will help to inform surgical planning and manage patient expectations¹⁹. In the present

study, leveraging quantitative measures of speech and swallowing we define factors influencing these crucial physiological functions and provide a valuable new patient cohort collected over a 20-year period. Of note, we report a high success of SVR with 71% of patients using this as a primary method of communication and only 14.1% of patients with a SVR not obtaining a useful voice.

The findings of this study support poorer functional outcomes with more radical pharyngeal resections. In circumferential resection of the pharynx there was a higher chance of communicating by writing, lower rate of successful SVR and lower rate of achieving a normal voice. These results mirror previous work demonstrating that pharyngeal resection influences voice intelligibility and often leads to a deeper vocal tone²⁰⁻²². We also demonstrate worse swallowing function in TPL as compared to PPL and TL. Indeed, no patient undergoing TL and PPL were NBM at 6 months post-op, in contrast to 6.6% of TPL. Furthermore, we show a significant number of chronic swallowing difficulties with 67% of TL and 87% of TPL patients requiring a modified diet. In line with this, a recent study reported that only 42.9% ($n=7$) and 5.3% ($n=19$) achieved a normal diet after PPL and TPL, respectively²³. Therefore, our data support a significant number of patients requiring a modified diet after pharyngeal resection and the need for clear communication of this complication.

In this series, we show a clear trend towards worse swallowing outcomes in salvage surgery. In primary as compared to salvage procedures there was a higher use of SVR, increased proportion managing a normal diet and less patients NBM. Interestingly, stratifying patients by extent of resection and salvage status showed each increased the risk of dysphonia and dysphagia, and accordingly the lowest rate of a normal diet was in salvage TPL at only 6.7%. Collectively, our results highlight previous radiotherapy and circumferential pharyngeal resection as key factors influencing functional outcomes, and suggest feeding regimes such as gastrostomy should be considered in salvage TPL given the high chance of requiring a modified diet.

Pharyngeal reconstruction remains an area of active research without consensus on a gold standard method^{24,25}. Our findings support better speech and swallowing outcomes in PPL and TPL with free tissue transfer as compared to regional flaps. Specifically, SVR was successful in 87.5% of PPL with a free tissue transfer ($n=8$) and 71.4% with a regional flap ($n=21$). There was

also a higher rate of obtaining a normal diet in TPL and PPL with free tissue transfer as compared to regional flaps. Nevertheless, the two patients NBM at 6 months (6.6%) both received a free tissue transfer in our cohort. Together, these results suggest free tissue transfer in TPL and PPL reconstruction may facilitate healing and one mechanism behind this could be through the recruitment a vascularized tissue composite to the neopharynx.

There are several limitations relevant when interpreting the findings of this study. Firstly, it is subject to omissions and collection bias common in clinical studies, particularly over an extended period. In addition, our data are limited to distinct points including the primary defect site, size, and grade without further information such as size of mucosal defect. The retrospective nature of this study also imposes limits into the interpretation of the results. Finally, there is a surgeon and case selection bias in larger tumours being are more likely selected for more aggressive surgical resection and therefore reconstruction.

Conclusion

Our results show SVR was successful in giving over 75% of TL and PPL patients an intelligible voice. In our cohort over 50% of all patients achieved an MDADI score of 5/5 with less than 2% NBM at 6 months post-op. Circumferential pharyngeal defects and prior radiotherapy had a significant impact on achieving a normal diet. In addition, we demonstrate that in TPL and PPL as compared to regional flaps free tissue transfer gives a higher rate of achieving a normal diet and successful use of SVR as well as providing a better speech quality. Crucially, moving forward prospective studies exploring functional outcomes in head and neck cancer will provide further insights into factors influencing functional outcomes in these common and challenging malignancies.

References

1. Sturgis, E.M. & Cinciripini, P.M. Trends in head and neck cancer incidence in relation to smoking prevalence. *Cancer* **110**, 1429-1435 (2007).
2. Hurren, A. & Miller, N. Voice outcomes post total laryngectomy. *Current opinion in otolaryngology & head and neck surgery* **25**(2017).

3. Farlow, J.L., *et al.* Speech and swallowing outcomes after laryngectomy for the dysfunctional irradiated larynx. *European Archives of Oto-Rhino-Laryngology* **277**, 1459-1465 (2020).
4. Bradley, P.J., Piazza, C. & Paderno, A. A roadmap of six different pathways to improve survival in laryngeal cancer patients. *Current opinion in otolaryngology & head and neck surgery* **29**, 65-78 (2021).
5. Yamazaki, H., *et al.* Radiotherapy for laryngeal cancer-technical aspects and alternate fractionation. *J Radiat Res* **58**, 495-508 (2017).
6. Elicin, O. & Giger, R. Comparison of Current Surgical and Non-Surgical Treatment Strategies for Early and Locally Advanced Stage Glottic Laryngeal Cancer and Their Outcome. *Cancers (Basel)* **12**, 732 (2020).
7. Putten, L., *et al.* Salvage surgery in post-chemoradiation laryngeal and hypopharyngeal carcinoma: outcome and review. *Acta Otorhinolaryngol Ital* **35**, 162-172 (2015).
8. Anschuetz, L., *et al.* Long-term functional outcome after laryngeal cancer treatment. *Radiation Oncology* **14**, 101 (2019).
9. McAuliffe, M.J., Ward, E.C., Bassett, L. & Perkins, K. Functional Speech Outcomes After Laryngectomy and Pharyngolaryngectomy. *Archives of Otolaryngology–Head & Neck Surgery* **126**, 705-709 (2000).
10. Karri, V., *et al.* Total pharyngolaryngectomy and voice reconstruction with ileocolon free flap: Functional outcome and quality of life. *Journal of Plastic, Reconstructive & Aesthetic Surgery* **64**, 911-920 (2011).
11. Gadepalli, C., de Casso, C., Silva, S., Loughran, S. & Homer, J.J. Functional results of pharyngolaryngectomy and total laryngectomy: a comparison. *The Journal of Laryngology & Otology* **126**, 52-57 (2011).
12. Roux, M., *et al.* Primary total laryngectomy and pharyngolaryngectomy in T4 pharyngolaryngeal cancers: Oncologic and functional results and prognostic factors. *European Annals of Otorhinolaryngology, Head and Neck Diseases* **134**, 151-154 (2017).
13. Meulemans, J., *et al.* Functional Outcomes and Complications After Salvage Total Laryngectomy for Residual, Recurrent, and Second Primary Squamous Cell Carcinoma of the Larynx and Hypopharynx: A Multicenter Retrospective Cohort Study. *Frontiers in Oncology* **10**(2020).
14. Surkin, M.I., Lawson, W. & Biller, H.F. Analysis of the methods of pharyngoesophageal reconstruction. *Head & Neck Surgery* **6**, 953-970 (1984).
15. Germain, M.A., *et al.* Reconstruction with Free Jejunal Autograft after Circumferential Pharyngolaryngectomy: Eighty-Three Cases. *Annals of Otology, Rhinology & Laryngology* **107**, 581-587 (1998).
16. Sharp, D.A., Theile, D.R., Cook, R. & Coman, W.B. Long-term functional speech and swallowing outcomes following pharyngolaryngectomy with free jejunal flap reconstruction. *Annals of plastic surgery* **64**, 743-746 (2010).
17. Chen, A.Y., *et al.* The Development and Validation of a Dysphagia-Specific Quality-of-Life Questionnaire for Patients With Head and Neck Cancer: The M. D. Anderson Dysphagia Inventory. *Archives of Otolaryngology–Head & Neck Surgery* **127**, 870-876 (2001).
18. Lam, P., Stanschus, S., Zaman, R. & Cichero, J.A.Y. The International Dysphagia Diet Standardisation Initiative (IDDSI) framework: the Kempen pilot. *British Journal of Neuroscience Nursing* **13**, S18-S26 (2017).
19. Mendelsohn, M., Morris, M. & Gallagher, R. A comparative study of speech after total laryngectomy and total laryngopharyngectomy. *Archives of otolaryngology--head & neck surgery* **119**, 508-510 (1993).
20. Mahalingam, S., Srinivasan, R. & Spielmann, P. Quality-of-life and functional outcomes following pharyngolaryngectomy: a systematic review of literature. *Clinical otolaryngology : official journal of ENT-UK ; official journal of Netherlands Society for Oto-Rhino-Laryngology & Cervico-Facial Surgery* **41**, 25-43 (2016).

21. Perez-Smith, D., Wagels, M. & Theile, D.R. Jejunal free flap reconstruction of the pharyngolaryngectomy defect: 368 consecutive cases. *Journal of plastic, reconstructive & aesthetic surgery : JPRAS* **66**, 9-15 (2013).
 22. Clarke, P., Radford, K., Coffey, M. & Stewart, M. Speech and swallow rehabilitation in head and neck cancer: United Kingdom National Multidisciplinary Guidelines. *J Laryngol Otol* **130**, S176-S180 (2016).
 23. Perdoni, C.J., Santarelli, G.D., Koo, E.Y., Karakla, D.W. & Bak, M.J. Clinical and functional outcomes after total laryngectomy and laryngopharyngectomy: Analysis by tumor subsite, salvage status, and extent of resection. *Head & neck* **41**, 3133-3143 (2019).
 24. Meulemans, J., *et al.* Functional Outcomes and Complications After Salvage Total Laryngectomy for Residual, Recurrent, and Second Primary Squamous Cell Carcinoma of the Larynx and Hypopharynx: A Multicenter Retrospective Cohort Study. *Front Oncol* **10**, 1390 (2020).
 25. Wenig, B.L., Keller, A.J., Levy, J., Mullooly, V. & Abramson, A.L. Voice restoration after laryngopharyngoesophagectomy. *Otolaryngology--head and neck surgery : official journal of American Academy of Otolaryngology-Head and Neck Surgery* **101**, 11-13 (1989).
-

	Total (n = 155)	TL (n = 85)	PPL (n = 32)	TPL (n = 38)	
Age	67.3 (44 – 86)	63.9 (47 - 86)	69.8 (42-78)	64.4 (44-80)	44
Sex					
Male	91	50	20	21	
Female	64	35	12	17	
Performance Status	1 (0 - 3)	1 (0 - 3)	1 (0 - 2)	1 (0 - 3)	
Location					
Supraglottis	27	15	6	6	
Glottis	86	65	9	12	
Subglottis	7	5	0	2	
Hypopharynx	30	0	17	13	
Oesophagus	4	0	0	4	
Grade					
Well	6	10	2	6	
Moderate	94	63	22	27	
Poor	15	12	8	5	
T Stage					
T0	1	1	0	0	
T1	9	6	1	2	
T2	15	8	5	2	
T3	49	29	14	6	
T4	81	41	12	28	
N Stage					
Nx	1	1	0	0	
N0	60	24	6	12	
N1	15	27	5	13	
N2	36	19	20	9	
N3	3	14	1	1	
Post-operative Rx					
Yes	56	33	22	15	
No	59	52	10	23	
Procedure					
Primary	104	56	25	23	
Salvage	51	29	7	15	
Flap					
Direct closure	72	68	0	4*	
Pectoralis major	20	5	14	1	
ALT	34	0	6	28	
Supraclavicular	13	3	7	3	
FAMM	7	0	5	2	
Radial forearm	2	0	2	0	
Temporalis	1	0	1	0	
LD	3	0	2	1	

Table 1. Patient, treatment and reconstruction characteristics, *pull-up only.

Resection	<i>n</i>	Communication	Percent
<i>TL</i>	65	SVR	76.5
	7	Electrolarynx	8.2
	12	Mouthing	14.1
	1	Writing	1.2
<i>PPL</i>	24	SVR	75.0
	2	Electrolarynx	6.3
	5	Mouthing	15.6
	1	Writing	3.1
<i>TPL</i>	21	SVR	55.3
	4	Electrolarynx	10.5
	10	Mouthing	26.3
	3	Writing	7.9

Table 2. Method of communication by extent of pharyngeal resection.

<i>Resection</i>	<i>n</i>	Voice Quality	Percent
<i>TL</i>	59	Tonic	69.4
	5	Hypotonic	5.9
	3	Hypertonic	3.5
	12	SVR, no voice	14.1
	6	No SVR	7.1
<i>PPL</i>	20	Tonic	62.5
	3	Hypotonic	9.4
	2	Hypertonic	6.3
	3	SVR, no voice	9.4
	4	No SVR	12.5
<i>TPL</i>	19	Tonic	50.0
	2	Hypotonic	5.3
	1	Hypertonic	2.6
	7	SVR, no voice	18.4
	9	No SVR	23.7

Table 3. Voice quality by extent of pharyngeal resection. Tonic is defined as a normal voice.

<i>Resection</i>	<i>Reconstruction</i>	<i>Normal voice(n)</i>	<i>Normal Voice (%)</i>	<i>SVR (n)</i>	<i>SVR (%)</i>
<i>TL</i>	DC	49	73.1	53	79.1
	Regional	9	52.9	11	64.7
	Free	1	100.0	1	100.0
	Pull up	0	0	0	0
<i>PPL</i>	DC	2	66.7	2	66.7
	Regional	13	61.9	15	71.4
	Free	5	62.5	7	87.5
	Pull up	0	0	0	0
<i>TPL</i>	DC	2	100.0	1	50.0
	Regional	0	0	0	0
	Free	15	50.0	18	60.0
	Pull up	2	50.0	2	50.0

Table 4 . Proportion of patients with a normal ‘tonic’ voice and using SVR as primary means of communication by nature of resection and method of reconstruction.

Procedure	Communication	<i>n</i>	%
Salvage	SVR	32	62.7
	Electrolarynx	5	9.8
	Mouthing	13	25.5
	Writing	1	2.0
Primary	SVR	78	75.0
	Electrolarynx	8	7.7
	Mouthing	14	13.5
	Writing	4	3.8

Table 5. Method of communication by salvage status.

Procedure	Voice Quality	<i>n</i>	%
Salvage	Tonic	28	54.9
	Hypotonic	3	5.9
	Hypertonic	2	3.9
	SVR, no voice	7	13.7
	No SVR	11	21.6
Primary	Tonic	70	67.3
	Hypotonic	7	6.7
	Hypertonic	4	3.8
	SVR, no voice	15	14.4
	No SVR	8	7.7

Table 6. Proportion of patients with a normal ‘tonic’ voice by salvage status.

	Flap	<i>n</i>	Normal (%)	NBM (%)	MDADI (score)
TL					
	None	67	46.2	0.0	4.6
	Regional	17	35.3	0.0	4.1
	Free	1	0.0	0.0	5.0
PPL	Pull up	0	NA	NA	NA
	None	3	33.3	0.0	3.3
	Regional	21	33.3	0.0	4.1
TTL	Free	8	87.5	0.0	4.5
	Pull up	0	NA	0.0	NA
	None	2	50	0.0	5.0
	Regional	2	0.0	0.0	2.5
	Free	30	23.3	6.6	3.6
	Pull up	4	25.0	0.0	3.3

Table 7. Swallowing outcomes by resection status and method of reconstruction.

Procedure	Resection	<i>n</i>	Normal diet (%)
Salvage	TL	13	44.8
	PPL	2	28.6
	TPL	1	6.7
Primary	TL	24	42.9
	PPL	9	36.0
	TPL	8	34.8

Table 8. Percentage of patients who achieve a normal diet (IDDSI = 7) by salvage status.